

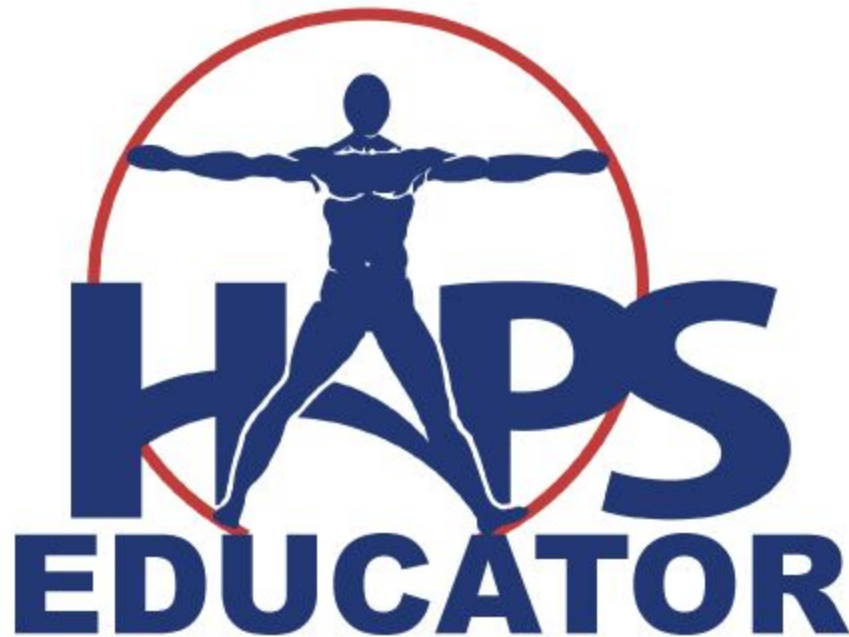
**The Survival of the Physiologist: A Human Anatomy and Physiology Game**

Vicki Abrams Motz, Timothy Koneval, Jill Bennett-Toomey, Rema G. Suniga and Jacqueline Runestad Connour

Corresponding Author: [v-motz@onu.edu](mailto:v-motz@onu.edu)

HAPS Educator. Vol 23 (1), pp. 37-44. Published April 2019.

<https://doi.org/10.21692/haps.2019.006>



Motz V, Koneval T, Bennett-Toomey J, Suniga RG, Runestad Connour J (2019). The Survival of the Physiologist: A Human Anatomy and Physiology Game. *HAPS Educator* 23 (1): 37-44. <https://doi.org/10.21692/haps.2019.006>

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# The Survival of the Physiologist: A Human Anatomy and Physiology Game

Vicki Abrams Motz, PhD, Timothy Koneval, PhD, Jill Bennett-Toomey, PhD, Rema G. Suniga, PhD, Jacqueline Runestad Connour, PhD

Ohio Northern University, Department of Biological and Allied Health Sciences. Ada, OH

[v-motz@onu.edu](mailto:v-motz@onu.edu), [t-koneval@onu.edu](mailto:t-koneval@onu.edu), [j-bennett-toomey@onu.edu](mailto:j-bennett-toomey@onu.edu), [r-suniga@onu.edu](mailto:r-suniga@onu.edu), [j-connour@onu.edu](mailto:j-connour@onu.edu)

## Abstract

Board games continue to increase in popularity and the pedagogical value of games has been repeatedly supported. Games keep students engaged and the level of engagement translates directly into time spent playing, and correspondingly, time spent reviewing course material. Therefore, game play is expected to result in greater student success. "The Survival of the Physiologist: An Anatomy and Physiology Game" was developed to involve competition between teams, with opportunities for collaboration among players. Anatomy and physiology students ( $n=50$ ) rated the game  $4.4 \pm 0.8$  on a scale of 1-5. Educators who played the game at the HAPS workshop ( $n=41$ ) rated it  $3.8 \pm 0.8$ . Additionally, beta tester educators ( $n=4$ ) rated it  $4.5 \pm 0.9$  in their own classrooms. Ninety-one percent of students surveyed and 82.9 percent of educators rated it a good tool for learning the material of anatomy and physiology. Among the HAPS educators at the workshop, question coverage was ranked at  $4.4 \pm 0.8$  with 90.2% of them indicating the level of difficulty was just right. Currently we are discussing developing a computer version of the game. <https://doi.org/10.21692/haps.2019.006>

**Key words:** educational board games, active learning, cooperative learning, anatomy & physiology

## Introduction

Beginning in the 1980's, much pedagogical emphasis has been placed on active learning and cooperative learning (Faust & Paulson 1998). The caveat is that increased time and effort are required to do these methodologies well. However, such effort is fruitful in that student academic success has been definitively linked to the introduction of interactive learning, including game play, into the teaching panoply (Montrezor 2016).

The context of game play (classroom/home; in person/online) affects its efficacy for learning (Aburahma and Mohamed 2015). In 2011, Sauve et al. reported on a systematic review of studies highlighting the game elements that support motivation and learning. These included repetition, learning, content segmentation, feedback, challenge, competition, active participation, teamwork, and interaction. Janssen et al. (2015) found that teamwork especially was found to enhance enjoyment, length of play time and, thus, retention. The game presented in the current paper contains elements of all of these factors.

Even at the graduate level, educational games have been shown to assist in mastery of material. Anyanwu (2014) found that incorporation of game play (*Anatomy Adventure*, published by *Know Yourself*) into the Anatomy coursework of medical and dental students helped to alleviate negative factors. These can include fear, loss of concentration, loss of interest in the course, lack of confidence, and undue stress. Similarly, Cain et al. (2014) found that framing learning in game terms, or gamification, increased student interest, motivation, and engagement.

It has been demonstrated that computer games, which use action rather than explanation, communicate complex ideas and reinforce mastery of concepts (Charles and McAlister 2004; Holland et al. 2002). They are particularly effective because of their accessibility to students with various learning styles.

Undergraduate students in upper level classes are more likely to engage in productive collaborative study than those in lower level classes (Ventimiglia 1994). Thus, this game was designed to have sufficiently challenging elements to maintain student interest, what Linn et al. (2010) describe as "desirable difficulties". Game tactics use whole-class collaboration and within-class competition. Competition has been found to enhance learning (Nuland et al. 2014; Sauve et al. 2011). Our goal was to create an interactive review game for anatomy and physiology students taught at a level appropriate to our course objectives.

## Materials & Methods

### *The Premise of the game*

Players (the class) represent survivors of an apocalyptic event. They are trying to reach a location with the hope of finding other survivors and more permanent food and lodging. To get to "civilization", survivors must traverse four different environments and face the challenges of each environment.

### *Game Pieces*

*Six-sided dice* (one per player). The rolled value represents health status for the start of the game, with 6 being healthiest and 1 least healthy. Health status is altered during the game

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based on food and water availability and conditions found in each environmental challenge.

*Team markers* (we used brain-shaped erasers). These are used to mark progress along game board environments.

*Non-perishable food tokens* (we used beans). Each team starts with two. Players may use these to survive low food situations and may add them to supplies according to directions on individual environment boards.

*Attribute cards* (list skills, talents and issues). One or two are dealt to each player at the onset of game play. The attribute will determine ability of players to access food and water, survive challenges, and avoid loss of health (Figure 1).

*Hexagonal environments* (serve as the game board). Environments have a central pictorial representation of the habitat. They also have a series of "squares" around the periphery that players proceed along as they answer questions from a card pack. At the end of a turn, the square landed on may be blank, have additional challenges, or present consequences which affect food, water or health status (Figure 2).

*Hexagon completion token* (awarded each time a team completes a hexagonal environment). These count as points in the final game tally.

*Death token* (black chips "awarded" to each team if a player is lost to death). These count as negative points in final game tally

*Tools tokens* (represent individual tools, such as knife, rope or fishing pole that can be used creatively by team members to meet environmental challenges). Tool tokens are placed upside-down on the playing surface, and each team gets one

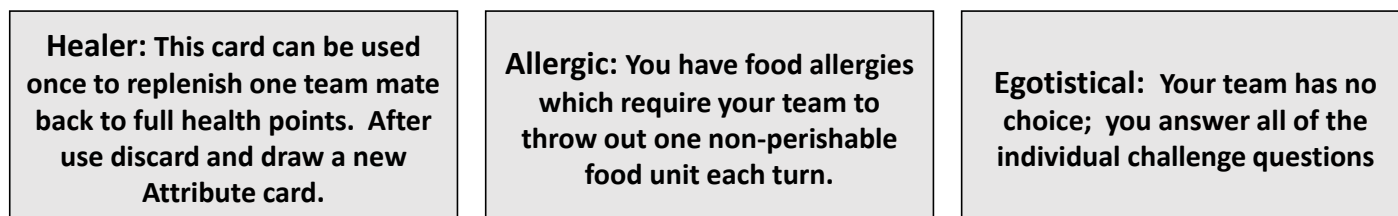
tool at the onset of play. Tools are returned to the pile upside-down after use. More tools can be gained by landing on appropriate environmental spaces.

*Food and water resource dice* (Sixteen dice, color-coded for perishable food (green), non-perishable food (brown), water (blue) and no survival resource (silver). Each six-sided die has two green faces, two blue faces, one brown face, and one silver face. These are rolled at the end of each turn to determine resource status.

*Group question cards* (400 questions covering both anatomical and physiological aspects of Anatomy and Physiology). Survivor groups may answer without multiple choice options and progress two squares for each correct answer, or opt for multiple choice and progress only one square for a correct answer (Figure 3A).

*Individual question cards* (One member of a team landing on an individual question square at the end of their turn must answer an individual challenge question). Individual challenges involve deeper conceptualization and application of knowledge as opposed to simple memorization. A correct answer moves the team ahead one space (Figure 3B).

*Whole-class question challenge cards* (used when a team lands on a whole-class challenge question square at the end of their turn). All class members work together to answer it. A correct answer moves all teams forward one square. Whole class challenges are designed to encourage collaboration, and they require a greater wealth of information about a single system. Examples include naming all of the carpal bones, or listing the capillary beds of the kidneys with associated nephron segments (Figure 3C).



**Figure 1.** Attribute card examples

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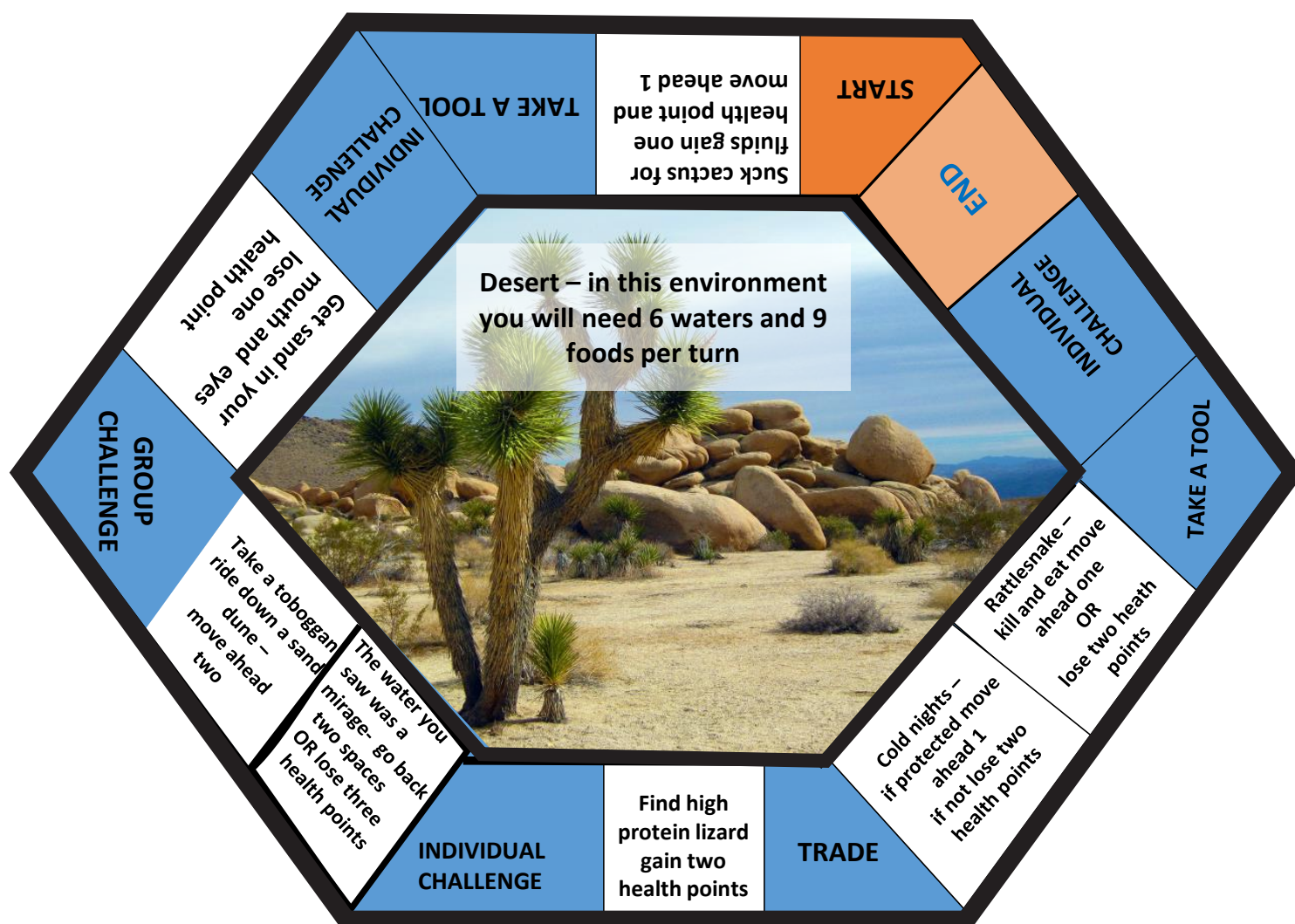


Figure 2. Hexagon environment prototype.

<p><b>Which type of bone development starts with a cartilage model?</b></p> <ul style="list-style-type: none"> <li>• Appositional</li> <li>• Endochondral</li> <li>• Intramembranous</li> <li>• Spongy</li> </ul> <p style="text-align: right;"><b>A</b></p>	<p><b>Which three organ systems cooperate to produce voluntary locomotion?</b></p> <ul style="list-style-type: none"> <li>• Skeletal</li> <li>• Muscular</li> <li>• Nervous</li> </ul> <p style="text-align: right;"><b>B</b></p>	<p><b>Name all of the cranial bones.</b></p> <ul style="list-style-type: none"> <li>• Sphenoid</li> <li>• R&amp;L Parietal</li> <li>• Occipital</li> <li>• Frontal</li> <li>• Ethmoid,</li> <li>• R&amp;L Temporal</li> </ul> <p style="text-align: right;"><b>C</b></p>
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Figure 3. Examples of A. Group question card, B. Individual question card, C. Whole class question card.

## Instructions

At the onset of the game, each team of 3-5 players turns over their first hexagon and places a team marker on the starting square.

Each individual player rolls a numbered die to obtain initial health status.

The team with the highest total health points goes first and the play proceeds clockwise.

Each team will have 90 seconds to answer as many questions as they can answer correctly. Alternately, the instructor can limit the number of questions per turn. Either the instructor or a member of another team draws a question card from the top of the Team Card pile. The team marker is moved as described under "Group question cards". A card cannot be skipped unless the instructor removes it. In the case of incorrect answers, the card is set aside until the end of their turn.

The team will follow the directions only on the square they land on at the end of the turn. If the consequences of the square redirect them to another square they do not follow the directions on the new square.

At the end of their turn, the team rolls the food and water resource dice and tallies their obtained resources:

- Green – Perishable Food
- Brown - Non-perishable Food
- Blue – Water
- Silver – No resource

The total of food resources must meet the environment requirement.

- If brown total exceeds required resources, an equivalent number of non-perishable food tokens are awarded to the team.
- If food count falls short of the requirement, teams can use non-perishable tokens to make up the missing food.
- If they cannot meet the food requirement, they lose one health point from any group member for each insufficiency.

The total water resources must be met.

- For every water resource not met, the team sacrifices one health point from the player of their choice.
- If they have excess water and a tool to carry it in, they may use it at a later turn.

At the end of each turn, survivors must have a health status greater than zero or that team member dies. When a team member dies, the black token is awarded and the "dead" player's attribute card(s) and health die are returned. The student takes on the role of a new survivor that joins the team (and gets new health and attribute card(s) at the start of the next turn.

If the team completes an environment hexagon, the team gets a marker and they turn over another hexagon and move to the new environment. The environment they have completed is returned upside down to the available environments pile. That team's turn ends when it gets the new hexagon and their team marker is placed in the starting position.

Questions incorrectly answered, which were held in reserve, can be "stolen". The instructor will reread the card, including the multiple choice hints; the first person raising their hand answers. If correct, their team advances one space on their own hexagon. If incorrect, their team goes back one square.

## The End

Once any one team has completed four environments the game ends.

Scoring final tally

Each hexagon completion token = 6

Each tool still in possession at the end = 2

Each non-perishable food or water resource at the end = 1

Each black death token = -4

## Variations

Instructors are encouraged to modify the game to best suit their needs. Game play can be arranged as review of a single topic as part of a lab; or as a review for a quiz or test covering many topics in lieu of lab or outside of lab. It could be included for a specified time in each lab, or used only occasionally.

## Assessment

The "Survival of the Physiologist" game play was introduced in our Anatomy and Physiology I (n=16 students), Anatomy and Physiology II (n=26), and Medical Physiology II (n=8) classes, in the spring semester of 2018, as a portion of a scheduled laboratory activity. Students in our classes (n=50) were given a pre-test consisting of 10 multiple choice questions prior to game play which were developed by faculty at Ohio Northern University (ONU) based on course content goals; and the same 10 questions were used as a post-test following game play. Following the first time the game was played, students were surveyed using a paper-based anonymous survey. The survey asked students to grade the game on a scale of 1-5 where 5 = A and 1 = F: "Was the game fun?", "Please rate game clarity", "Please rate game design/aesthetics" and "Give the course an overall grade". It also asked students as a yes/no question, "Did this help you learn the course material?" After the initial day of game play, students voluntarily played the game during subsequent laboratories as a time-filler while experiments were running.

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Because this game was so popular with students, it was presented as a workshop at the 2018 Human Anatomy and Physiology Society (HAPS) Annual Meeting in Columbus, OH (Motz *et al.* 2018). Approximately sixty people were in attendance. This far exceeded expectations; the room was crowded and noisy, and it was not possible to distribute rules to all participants. As a result, game play was set up for two groups with more players than recommended so everyone could participate. Following game play, forty-one of the attendees filled out evaluations grading the game for fun, clarity, and aesthetics on a scale of 1-5 where 5 = A and 1 = F. Participants also were asked if they felt the game was a good learning tool as a yes/no question, whether they felt the question level was too easy/ just right / or too difficult, and whether they wanted to participate as beta testers for the game. For all data, the number scale mean scores standard deviation were calculated.

Game boards, directions, game pieces and the same pre and post-test questions we used at ONU were provided to those who indicated an interest and were able to test the same two systems (muscular and skeletal) during the fall semester 2018-19 in their college classes.

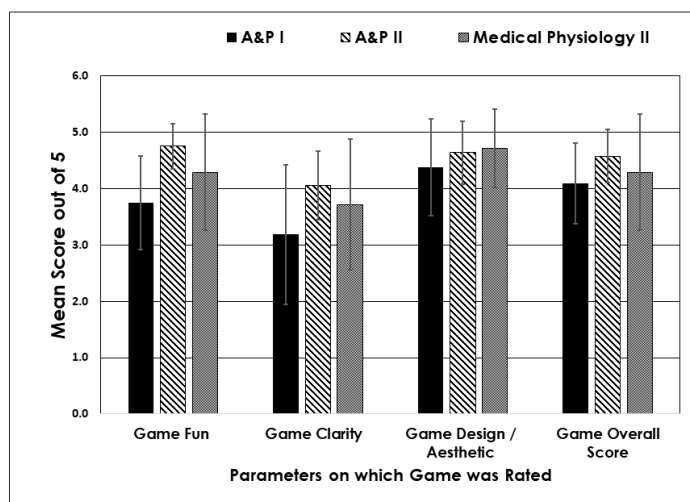
Based on student surveys, our own observations, and helpful comments from beta testers, modifications were made and development of an online version and patent is in progress.

## Results

The first time the game was played in our classes, at the HAPS meeting, and in beta test situations, there was a learning curve as to how play proceeded and how the game cards were utilized. Length of time spent playing was variable based on lab time available. Three rounds of play was possible at a minimum, and on other occasions students played for up to an hour. When students had the opportunity to play the game, and when Anatomy and Physiology II students who had played in Anatomy and Physiology I played again in the following semester, play moved more quickly each time it was played, as familiarity with the rules increased. Student enjoyment appeared (anecdotally) to increase as ease of play improved with particular enjoyment centering on the attribute cards and health status dice.

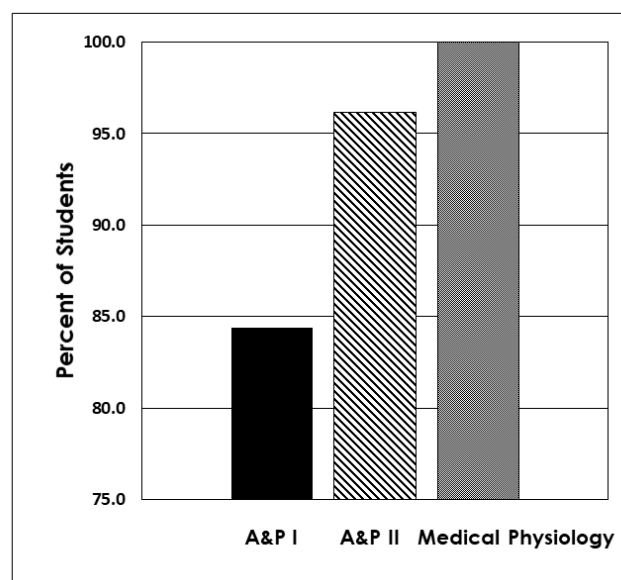
### *Student response to the game*

Student ratings of the game following the first time it was played, for fun, clarity, and aesthetics on a scale of 1-5 where 5 was best, had a mean overall rating for Anatomy and Physiology I, Anatomy and Physiology II and medical physiology students of 4.4 $\pm$ 0.8 (Figure 4).



**Figure 4.** Rating scores of students in Anatomy and Physiology I (n=16) Anatomy and Physiology II (n=26) and Medical Physiology (n=8) on basis of fun, clarity and aesthetics on a scale of 1-5 (where 5 = A and 1 = F). Error bars indicate standard deviation.

Additionally, students were asked whether or not they felt the game was a good learning tool. Ninety-one percent of students rated the game as a valuable tool to promote student learning (Figure 5).



**Figure 5.** Percent of students (n=50) who voted that yes, the game did help them to learn the course material.

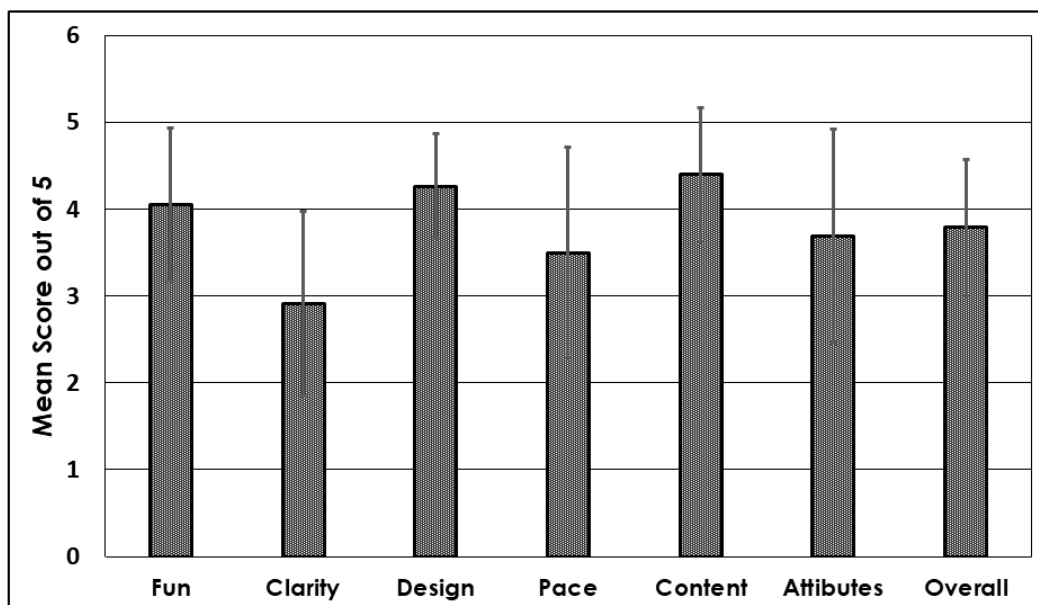
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*HAPS participant response to the game*

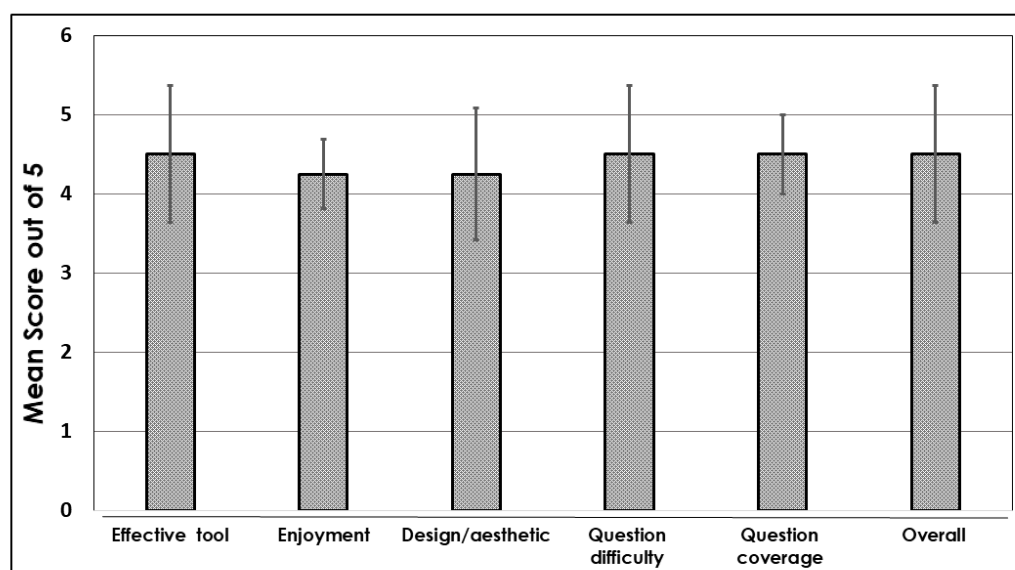
Overall, the HAPS attendees who filled out surveys rated the game  $3.78 \pm 0.78$  on a scale of 1-5 (Figure 3). In terms of being fun to play, it was rated  $4.04 \pm 0.88$ . Question content received an excellent rating of  $4.39 \pm 0.77$ . Ninety percent of respondents considered the questions to be at the right level of difficulty, with 7% finding them too difficult and 2% rating them too easy. Eighty-three percent of respondents felt the game was a good learning tool and 48.7% expressed an interest in beta testing the game in their class. The biggest criticism of the game was that the rules were fairly complicated. Clarity of play was rated at only  $2.9 \pm 1.1$  (Figure 6).

*Beta tester response to the game*

The muscular and skeletal system questions were chosen for beta- testing using two environmental hexagons in six classes taught by four educators. Rather than providing all of the game pieces, game progress was tracked on a score sheet. Two educators played it only once with their classes, one played it twice and one played it three times. Educators administered a pre-test before the first game play and an identical post-test after that session as described above. Mean scores ( $\pm$  standard deviation) improved  $10.7 \pm 3.3\%$  from a pre-test score of  $62.5 \pm 4.5$  to a post-test score of  $73.2 \pm 6.6$ . Before game play only  $32.1 \pm 13.9\%$  of students scored above a 70% whereas after game play  $79.5 \pm 16.9\%$  of students scored above a 70%. Participating faculty rated the game for: its effectiveness as a review (teaching) tool, student enjoyment, game design, aesthetic appeal, question difficulty, and coverage. They also assigned an overall score. All mean scores were between 4.3 and 4.5 for all parameters (Figure 7).



**Figure 6.** Ratings on a scale of 1-5 of game aspects (where 5 = A and 1 = F) by faculty attending the workshop at the 2018 HAPS meeting (n=41). Error bars indicate standard deviation.



**Figure 7.** Ratings by Beta-testers (n=4) on a scale of 1-5 (where 5 = A and 1 = F). Error bars indicate standard deviation.

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Feedback from Beta-testers indicated that the learning curve for the game was steep due to its complexity. The two educators who used the game more than once ranked it more highly than the two who used it only once. The “attributes” were cited as contributing largely to student enjoyment of the game, while counting beans and food points were less enjoyable aspects. The use of individual questions vs. team questions vs. whole class questions was the most controversial item. One tester explained that some questions were looking for interaction between multiple systems and not all of the material had been covered in class yet. Beta testers liked the coverage and question level; one beta-tester indicated that they would like to have a version of easier questions available to use with a lower level class.

## Discussion

Based on surveys of students and educators, “The Survival of the Physiologist: A Human Anatomy and Physiology Game” was deemed to be an enjoyable and effective learning tool for undergraduates taking anatomy and physiology courses. This is in keeping with many studies indicating that interactive game play increases learning success (Anyanwu 2014; Cain et al. 2014; Montrezor 2016). Based on student and educator feedback, some simplification of game mechanics would improve student enjoyment and decrease the steepness of the learning curve. The beta-testers were given score sheets that could be used to track health, and it is likely that we should expand this score sheet to track food, water and tools. Not only would it make playing the game easier as a board game, but it would also improve its projected development as a computer game. We are considering converting it into an electronic form since there is a large body of evidence supporting video games as effective delivery systems for knowledge acquisition (Boyle et al. 2016).

## Conclusion

Game play can be an effective tool to reach students of various learning styles both as board games and as video games. “The Survival of the Physiologist: A Human Anatomy and Physiology Game” game has promise as an educational resource and should be developed for general distribution.

## Acknowledgements:

We are grateful to HAPsters who attended our workshop, to our beta-testers for taking the time to pilot our game in their classrooms and to provide formative feedback, and to our students for their tolerance during game development.

## About the Authors

The authors are faculty members in the Department of Biological and Allied Health Sciences, Ohio Northern University who are actively involved in the use of interactive learning in their teaching methodologies. All authors teach in the full year cadaver-based human anatomy and physiology sequence geared toward nursing and exercise physiology majors. Additionally, Drs. Motz and Suniga and Bennett-Toomey team teach a year-long physiology course geared toward pre-meds, pharmacy majors and upper level allied health students, and Drs. Connour and Koneval teach anatomy courses.

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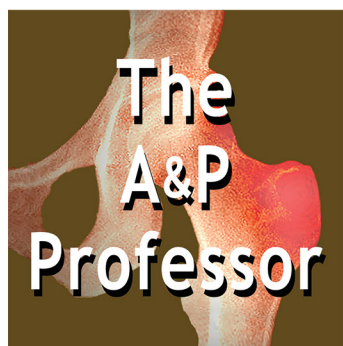
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